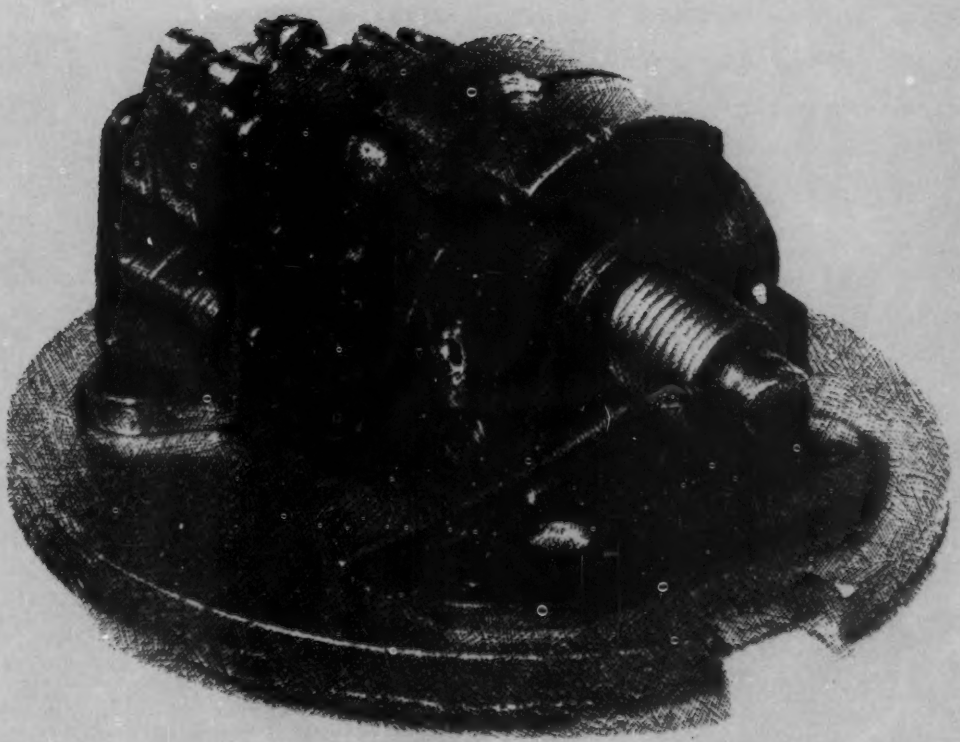
THE NATIONAL BUREAU OF STANDARDS / JULY 1973

Technical News Bulletin

The Public Need and the Role of the Innovator.

See page 161



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NATIONAL BUREAU OF STANDARDS

Technical News Bulletin

JULY 1973 / VOL. 57, NO. 7 / ISSUED MONTHLY

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U.S. DEPARTMENT OF COMMERCE
Frederick B. Dent, Secretary

Betsy Ancker-Johnson
Assistant Secretary
for Science and Technology

NATIONAL BUREAU OF STANDARDS
Richard W. Roberts, Director

Prepared by the NBS Office of Technical Information and Publications, Washington, D.C. 20234

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

The Institute for Computer Sciences and Technology

Center for Radiation Research

Center for Building Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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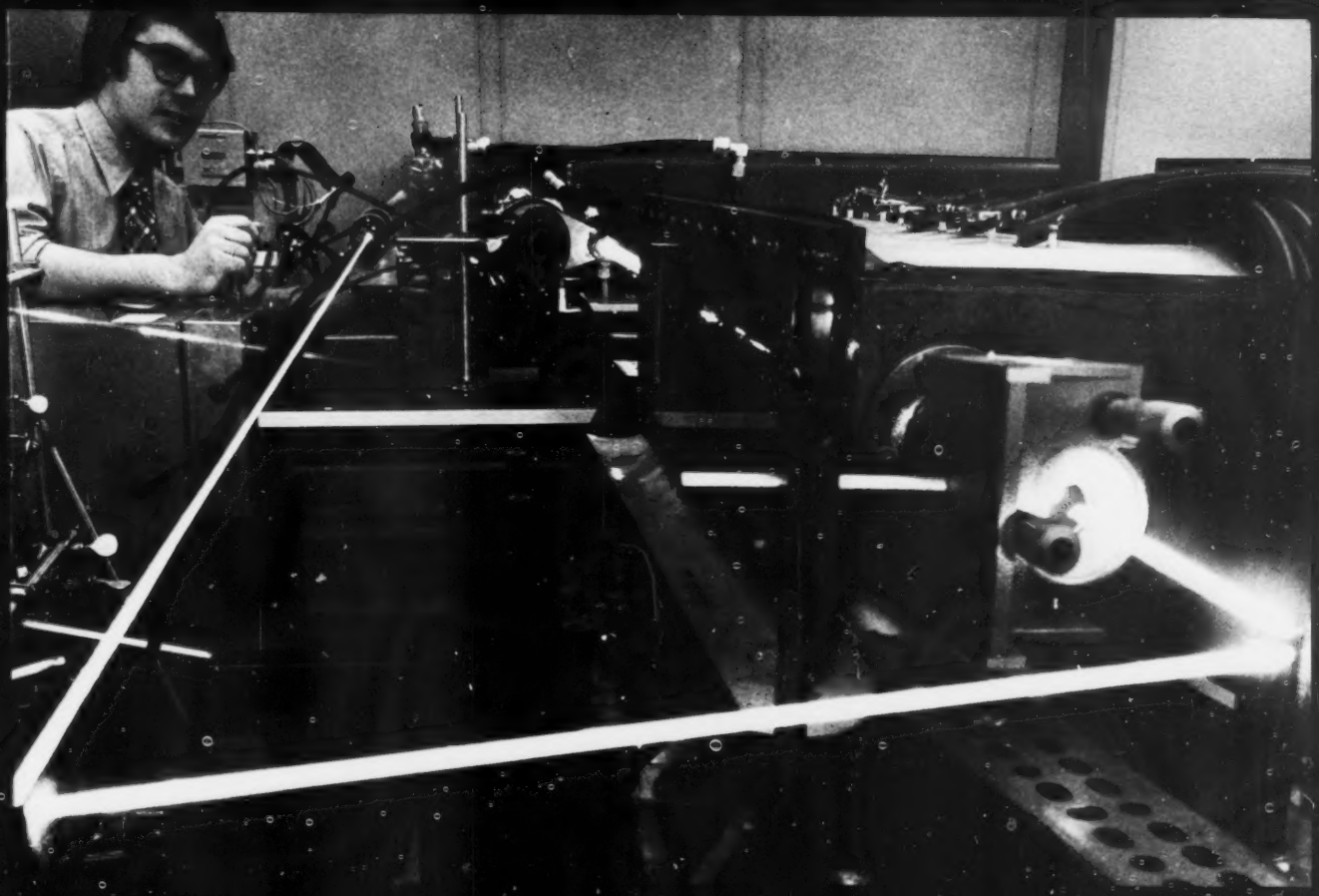

Dr. George H. Atkinson is shown using the dye laser to detect free radicals.

NBS USES LASER TO DETECT

FREE RADICALS

Scientists at NBS have developed a powerful technique for detecting free radicals with a dye laser. The free radicals are elusive, short-lived chemicals which play important roles in many photochemical reactions. Such areas of research as air pollution studies, flame research, flame inhibition, high-temperature chemistry, stratospheric kinetics, laboratory studies of planetary atmospheres, and development of

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FREE RADICALS *continued*

new laser systems involve free radicals.

The new NBS technique developed for studying free radicals produces them in a laser cavity. The free radicals—short-lived molecular or atomic fragments carrying an unpaired electron—are studied by observing the way they absorb the laser light.

Three absorption systems of NH_2 and one of HCO have already been detected in early test phases of the program. Even in these experiments, detection of free radicals was many times better with the dye-laser technique than with conventional approaches.

The dye-laser technique is also readily adaptable for obtaining information about the chemical dynamics and precise energy states—electronic, vibrational, and rotational—of the free radicals being studied, its developers say.[1] In their words, "The new technique makes short-lived fragments available for analysis, more easily than ever and at less cost."

EXPERIMENTAL DETAILS

The NBS experimental free radical detection system consists of three general parts: (1) a vacuum flash photolysis apparatus, (2) a flashlamp-pumped dye laser, and (3) a grating spectrograph.

The basic flash photolysis apparatus is a 75-cm-long fused silica reaction cell enclosed in an evacuable discharge chamber. Fused silica windows, wedged at 30°, are sealed to the cell at Brewster's angle. A triggered spark discharge through N_2 gas dissipates about 1000 J of energy along the length of the cell. The photolysis (reaction) cell is connected to a conventional gas handling system.

The coaxial, flashlamp-pumped dye laser provides output powers of about 300 mJ from rhodamine 6G in absolute ethanol for flashlamp input energies of about 90 J. The 2-meter-long cavity is formed by a 99 percent reflective, spherical (2-m radius of curvature) mirror and a 90 percent reflective, flat (wedged) output mirror. The entire flash assembly is inside this cavity. The output from the dye laser is focused into a 2-meter grating spectrograph. Spectra are recorded on photographic plates.

The visible light from the photolysis flash is detected during the experiments by a biplanar photodiode with a risetime of a few nanoseconds. The signal from the photodiode activates the delay circuit in an oscilloscope which, in turn, triggers the laser at a preselected time delay after the photolysis flash. Since the detecting laser pulse is about 0.1 times as long as the photolysis pulse (3-5 μs), the cell can be probed even during the photolysis process by simply changing the peak-to-peak delay time.

The technique is characterized by the developers as "... a powerful tool for obtaining high resolution absorption spectra as well as obtaining precise information about the energy distribution of transient species produced photolytically or kinetically. As such, the technique should have a marked impact on research and development in many areas."

[1] Atkinson, G. H., Laufer, A. H., Kurylo, M. J., Detection of free radicals by an intracavity dye laser technique, Journal of Chemical Physics, American Institute of Physics, New York, N.Y., July 1973.

ASTM/NBS Symposium on Spreading Resistance Measurements

A symposium on "spreading resistance" measurements for semiconductors will be held June 13-14, 1974, at the Bureau's Gaithersburg site. The American Society for Testing and Materials will cosponsor this conference.

Papers are solicited on the following subjects: Theory (Models of contacts and current flow, and correction factors and their computation for thin and multilayer structures); Equipment and Calibration (Mechanical assembly and probes, sample preparation, data acquisition and electronics, and standards); and Applications (Characterization of semiconductor starting materials, process control, and device evaluation.)

Persons desiring to contribute papers are requested to submit a descriptive title by September 1, 1973, and follow with a summary of no more than 1,000 words by December 15, 1973, to enable reviewers to determine suitability of the paper for the symposium.

Descriptive titles and summaries should be sent to:

Dr. James Ehrstein
National Bureau of Standards
Technology Building, Room B346
Washington, D.C. 20234
Telephone: 301/921-3625

Camera-ready copies of the papers must be submitted to Dr. Ehrstein prior to oral delivery of the paper. The Proceedings of the symposium will be published shortly after the meeting. Only those papers presented at the symposium will be published.

INITIATION OF GOVERNMENT-WIDE COMPILER TESTING FOR COBOL

Business-oriented computer programmers should soon be seeing improved quality and uniformity in the COBOL programming language, as a result of action by NBS, the General Services Administration, and the Department of Defense. These agencies have initiated a Government-wide Federal COBOL Compiler Testing Service (FCCTS) for COBOL compilers purchased or used by the Federal Government.

COBOL is the *CO*mmon *B*usiness *O*riented *L*anguage, originally introduced in the early 60's, which now serves as the medium for constructing perhaps 80 percent of computer programs for payroll, personnel, inventory, and similar management record processing. A COBOL compiler is the complex software which transforms the English-like statements of the COBOL language into the binary number patterns understood as instructions by computer hardware. There are several hundred distinct COBOL compilers being marketed today by computer companies, counting differences in hardware systems and compiler features.

The Federal COBOL Compiler Testing Service will be a centralized, comprehensive means to determine whether a compiler has correctly implemented the possible expressions and functions that are defined for COBOL by the Federal Information Processing Standard (FIPS 21) adopted in July 1972. Testing is also pertinent to the American National Standard COBOL (X3.23-1968), since it is the basis of the Federal Standard.

Under an agreement signed on April 16, 1973, between the Institute for Computer Sciences and Technology of NBS and DoD, NBS has delegated to DoD the authority to develop and maintain an NBS-approved COBOL Compiler Validation System (CCVS). The Navy ADP Equipment Selection Office (ADPESO) has been assigned the responsibility, and will perform cost-reimbursable test services based on the CCVS. NBS will publish guidelines for the performance of validation tests, and will resolve issues in interpretation of the Federal COBOL Standard, leading to improvements and new requirements for the CCVS.

The initial basis of the testing service will be the DoD COBOL Compiler Validation System,[1] a set of well-defined COBOL programs that has been under development since early 1971. Each of the 120 programs in the set is designed to test a few specific features of the COBOL language as defined in the Federal Standard. The CCVS includes a special control program to assist a test operator in selecting test routines according to the appropriate capability level of the COBOL Standard, and to maintain a record of the steps taken to set up a validation run.

The Federal COBOL Complier Testing Service will provide a major tool to Federal data processing administrators for achieving substantially greater compatibility and interchangeability among COBOL programs and automated information systems. As a centralized service, it will reduce costs and duplication in validation testing by individual agencies. As a rigorous audit of standards conformance, it will contribute to lower program conversion costs in transition from one computer to another, will shorten programmer retraining, and will ease the burden of program documentation.

More important perhaps for the benefit of all computer users and vendors is the introduction of a uniform, substantive methodology of quality assurance in the software field. From this starting point may grow standardized quality tests for other software components and more meaningful standards in the computer industry.

The NBS-DoD agreement permits cost-reimbursable tests to be requested by:

-vendors wishing to have a compiler validated for their own purposes;

-vendors wishing to have a compiler validated in response to a Government request for proposals;

-Government agencies involved in a procurement; or

-Government agencies wishing to validate a compiler already in use.

The computed results produced in a validation run will be reviewed by the Federal COBOL Compiler Testing Service, which will prepare a Validation Summary Report (VSR) for dissemination to the requestor and NBS. If a compiler has previously been validated on a similar computer configuration, the validation run need not be repeated, and the earlier VSR can be provided to a requestor. The VSR will

continued on page 174

Test site on top of 12-feet deep snow field at Crater Lake National Park, Oreg.

BUREAU STUDIES VHF ANTENNA PERFORMANCE UNDER SNOW CONDITIONS

Twelve feet of snow play funny tricks on signals from very-high-frequency (VHF) antennas. That's the conclusion of a study performed this winter for the Department of Defense (DoD) by the Bureau's Electromagnetics Division.

DoD asked the NBS Boulder (Colo.) laboratories to determine what effect, if any, snow has on the radiation properties and standing wave ratio (SWR) of small, vertically polarized, VHF antennas operating at 168 MHz.

Environment strongly influences antenna properties of VHF. Conditions that normally affect antenna performance include electrical properties of the ground, elevation of the antenna above the ground, and metallic objects in close proximity to the antenna. In this case, it was desirable to learn more about the effects of snow. Specifically, if a vertically polarized antenna is radiating energy while positioned at the surface or several feet below the surface of a snow field, how much change can be measured in the gain, pattern, and SWR when com-

pared to the same antenna on or elevated above dry ground?

Measurements made on dry ground were accomplished at a field site near Boulder. The same test antennas were moved to Crater Lake National Park, Oreg., where large snow fields still existed. At Crater Lake the antennas were operated both while buried 12-feet deep in the snow (at ground level) and at the snow-surface level.

Results of the NBS measurements indicated the following findings:

1. Antennas exhibited more gain on top of 12 feet of snow than on dry ground but less gain (10 to 15 dB) when buried under 12 feet of snow than on dry ground. The major contributing factor was not the change in SWR, but the dielectric effects of the snow.

2. SWR measurements did not change significantly whether the antennas were on dry ground (1.13 to 2.01) or on top of 12 feet of snow (1.57 to 3.40). However, they did change considerably when buried under 12 feet of snow (2.26 to approximately 10).

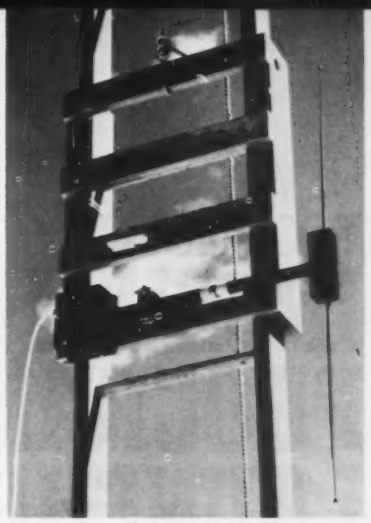
3. Antenna polarization did not change significantly except when the antenna was buried under 12 feet of snow, which in some cases caused the vertically polarized antenna to radiate a field more strongly polarized horizontally than vertically.

4. The azimuthal patterns of all but one of three test antennas were omnidirectional (<2dB). That antenna exhibited a 22-dB pattern variation when buried 12-feet deep in the snow.

Measurements on the test antennas buried in 12 feet of snow were not performed ideally because the snow immediately surrounding the antennas was of necessity disturbed and could not be replaced in a layered and stratified manner as snow is normally deposited. Ideally, the antennas should be deployed on dry ground in the fall and measurements made periodically throughout the winter as progressive snow depths accumulate.

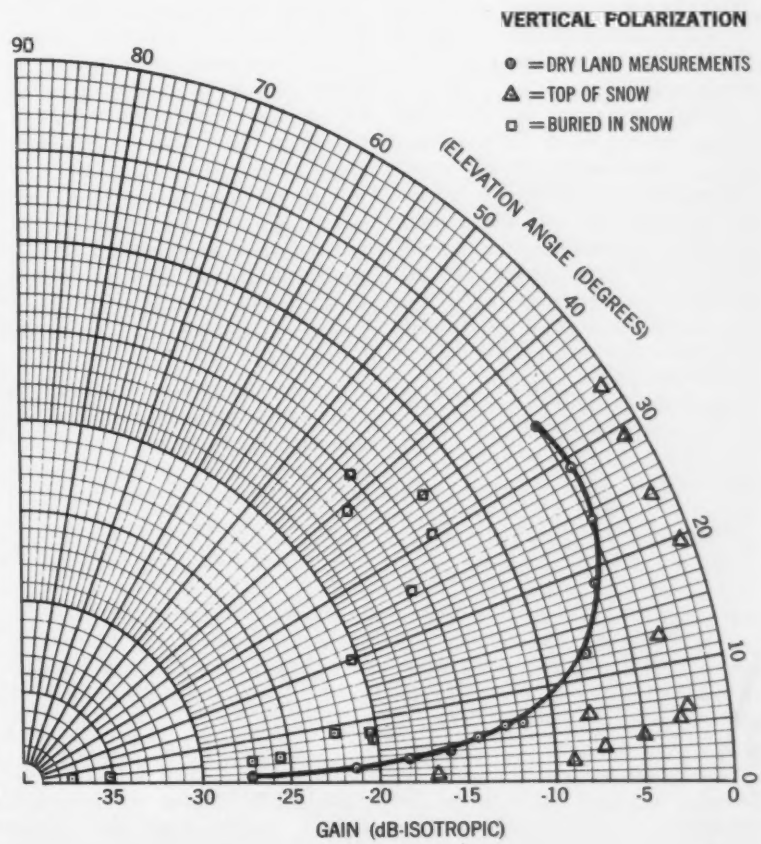
It is hoped that additional measurements can be performed to analyze completely the effects of snow, ice, slush, and other hostile environments on VHF antennas and to explain the differences observed in measurements taken on top of snow compared to those with the antennas buried in the snow at ground level.

A more complete analysis would be useful so that VHF antennas could be deployed in the field in the most effective locations and in the most efficient manner.



Nonmetallic mast includes movable slide to elevate vertically polarized dipole antenna up to 30 feet above the surface. By varying height and distance from transmitting antennas, measurements at various elevation angles could be performed.

Measured gain of one of three typical test antennas deployed under three environmental conditions.



NEW TECHNOLOGY INCENTIVES PROGRAM LAUNCHED

Dr. Richard W. Roberts, NBS Director, has announced that funding has become available for the Experimental Technology Incentives Program (ETIP).

ETIP, proposed by President Nixon in his fiscal 1973 budget, seeks to increase the nation's application of technological invention and innovation to such questions as productivity, unemployment, pollution, energy conservation, and unfavorable trade balances. ETIP will be closely coordinated with related programs conducted by the National Science Foundation.

Dr. Roberts said many of the experiments to be conducted under the program will be based on suggestions from various elements of the industrial community, professional and trade organizations, educational institutions, state and local governments, and individuals.

The program assumes that technological invention and innovation in the private sector is strongly influenced by the policies and programs of the Federal Government. This hypothesis will be tested by focusing on the following policy questions:

°What alternatives in federal or federally assisted procurement policies and practices would be cost-effective in stimulating technological invention and innovation and thereby increasing productivity and improving the U.S. competitive position?

°Can the regulations issued by the government to protect public health, safety, and well-being which control goods and services offered to the public be used to provide a positive stimulant to technological innovation?

°What cost-effective federal actions can be taken to improve the productivity of U.S. industry and its international competitiveness through facilitating the commercialization of the technical inventions of inventors and small R&D firms?

An initial allocation of $7 million has been granted to NBS for the ETIP program. Additional funding has been requested in the FY 1974 budget.

According to Dr. F. Karl Willenbrock, Director of the ETIP program, NBS is now defining the desired experiments and statements of work for each of the three major policy questions, after which participation will be solicited from the private sector. Most of the experiments will be performed in cooperation with technologically oriented private organizations and other federal agencies. NBS will monitor progress of these investigations.

As one of its earliest efforts, ETIP supported the June 11-14 Conference on the Public Need and the Role of the Inventor.

In addition to the above three initial focal areas, the program will conduct analyses and exploratory studies to provide an improved basis for choice of other Federal Government policy questions for future investigation.

Further information on the ETIP program plan and guidance for submittal of suggestions can be obtained by contacting:

Director, Experimental Technology Incentives Program
National Bureau of Standards
Administration Building, Room A724
Washington, D.C. 20234

TOP INNOVATORS MEET TO DISCUSS **CAUSES AND REMEDIES**

Behold the inventor—speeding to the bank in a chauffeured limousine, laughing all the way, about to make another deposit of money pouring in from his latest brilliant idea. . . .

"If that's your notion of the typical modern-day Edison, forget it," says Jacob Rabinow, chief research engineer of the Bureau's Institute for Applied Technology and one of America's leading inventors. At the June 11-14 conference on The Public Need and the Role of the Inventor (sponsored by NBS for the Department of Commerce, with the cooperation of the National Inventors Council), Rabinow observed ruefully:

"Nowadays, when an inventor's on the way to the bank, he's probably *crying* all the way because he has to borrow money to finance his latest quixotic gamble. That's one of the problems we explored at our conference held at the recommendation of the National Inventors Council, the advisory body for the NBS Office of Invention and Innovation.

"It's not just a personal problem of the independent inventor. The whole country is handicapped when economic and social conditions discourage invention and innovation. We've got to determine why the United States has dropped to seventh place among nations noted for a high level of invention productivity. We need to reassure men and women of ideas that opportunity still beckons to the independents from whom may come revolutionary new inventions comparable in impact to the electric light bulb, space

rocketry, xerography, the mercury dry cell, the transistor...."

The new Assistant Secretary of Commerce for Science and Technology, Dr. Betsy Ancker-Johnson, spoke at the first luncheon session.

The conference's banquet speaker was Dr. Richard W. Roberts, who early this year was plucked from his post as General Electric's research and development manager of materials science and engineering to become NBS director. Roberts—whose GE staff achieved such technological advances as the first gem quality man-made diamonds, a revolutionary solid-waste recycling process, medical sensors and diagnostic devices, and unique space-age metal machining tools—emphasized that as a high-technology nation by birth, tradition, and necessity, the United States "cannot afford to neglect the nature and the nurture of inventors and their ideas." Citing historic precedents as well as current challenges, he pointed out, for example that:

"The Constitution provided for patent protection, and one reason President Jefferson commissioned the Lewis and Clark expedition was to identify natural resources that could be developed economically. Fulton and his steamboat, Whitney and the cotton gin, McCormack and his reaper all had tremendous impact on the Nation's economy. The flourishing of American science after the Civil War led to the 'green revolution' in agriculture and strongly contributed to the industrialization of the nation."

Chairman Charles Stark Draper of the National Inventors Council, a noted aerospace and astronautics innovator and M.I.T. professor-emeritus, keynoted the conference opening proceedings that probed in depth at many points on the invention-innovation battlefront, including: proposed changes in the patent system; trends in technological policy-making; the generation of new enterprise; the motivations of developers, producers, and marketers; inventor-entrepreneurship and national priorities; invention and innovation in the universities; antitrust doctrine vs. the individual inventor; the role of inventors in large corporations and industrial laboratories; and European approaches to the stimulation of invention.

Among other featured speakers were: Dr. Robert D. Tollison, senior staff economist of the Council of Economic Advisors; Dr. Daniel V. De Simone, executive director of the Federal Council for Science and Technology; Dr. Richard S. Morse, president ot the M.I.T. Development Foundation; Dr. William B. McLean, technical director of the Naval Undersea Research and Development Center; Dr. Narinder Kapany, electro-optics specialist and Stanford University physics professor; Prof. James Adams, Stanford University mechanical engineering department; Dr. William Bradford Shockley, inventor of the junction transistor and Stanford University engineering science professor; Prof. John Stedman of the University of Wisconsin law faculty; Arthur R. Whale of the Dow Chemical Co. patent department; Edward J. Brenner, executive director of the Association for the Advancement of Invention and Innovation, and former U.S. Commissioner of Patents; Prof. Irving Kayton of George Washington University's national law center; Dr. C. E. Anagnostopoulos, general manger of the Monsanto Co.'s New Enterprise Division; David DeWitt, radio, radar, and semiconductor device innovator and IBM Fellow; Dr. Jan Rajchman, information sciences vice-president for RCA's David Sarnoff Research Center; Dr. Frederik Neumeyer, consultant in international industrial property law, Sweden; and Dr. Harald Romanus of the Swedish Board for Technical Development.

These speakers and other participants exchanged views on many complicated and controversial aspects of invention and innovation at informal, free-wheeling workshop and discussion sessions throughout the conference.

Participants were encouraged to address themselves to a couple of dozen basic questions, ranging from the deceptively simple "What is an invention?" and "What do we *want* from our inventors?" to challenges of a more specific nature, such as "Is there a need for a Foundation/Institute/Non-profit Corporation to help the inventor?" Perhaps the single question which best epitomized the conference's thrust is this:

"How do we get an idea from the drawing board to the drawing room?"

The speakers addressed this question from various approaches.

Dr. Betsy Ancker-Johnson summarized the large research and development expenditures by Government and the private sector as a preliminary to considering what incentives might be offered to the Government inventor, to encourage his efforts, and to the private sector, to facilitate and increase the transfer of Government-owned technology to civilian markets. On the latter question, the key might be to change the current practice of issuing generally nonexclusive licenses for Government-owned patents.

"The truth is that we know of very few products or processes from Government-sponsored technology that have reached civilian markets. In one study, mostly of Department of Defense inventions, only 12 percent were commercialized.

"A simple statistical comparison between the number of Government-owned patents, on the one hand, and privately-owned patents, on the other, shows an imbalance favoring the private sector. Last year there were 3200 patents issued on Government inventions. While Government's R&D expenditures are 50 percent higher

On the first National Inventor's Day, February 11 (which also happens to be the anniversary of Thomas Edison's birthday), Robert Gottschalk (left), Commissioner of Patents, presented a citation from the American Patent Law Association to Jacob Rabinow (right), Director of the Bureau's Office of Invention and Innovation, while Dr. Richard W. Roberts, Director of NBS, observes. The citation noted Rabinow's "many significant contributions as an inventor...his unique ability to stimulate others to create and innovate, and...his continuing support of the principles of the patent system through his service in industry and government." On May 4 Rabinow also received its prestigious Jeffersonian Gold Medal from the New Jersey Patent Law Association (a division of the American Patent Law Association).

than industry's, its proportion of patents issued is ridiculously low—less than 5 percent of the more than 70,000 domestic patents per year.

"In an effort to speed the commercialization of Government-sponsored inventions by private industry the President last year directed the Secretary of Commerce to develop 'plans to promote actively the licensing of Government-owned patents.'

"Several steps have been taken, in response, by the Department. For one thing, our National Technical Information Service (NTIS) has launched a patent promotion program aimed at carrying out the President's directive. Every Wednesday there is published in the *Federal Register* a number and title listing of patents and patent applications available for licensing. And NTIS has published a special issue of its *Weekly Government Abstracts* devoted to Government Technology for Licensing.

"Another step is that Battelle Memorial Laboratories of Columbus, Ohio, has selected for NTIS about 40 Government patents and patent applications on which it has developed special communications packages.

"A third step is that the General Services Administration has issued new regulations permitting the exclusive licensing of Government-owned patents. This endeavor is being challenged in the courts, so it has not yet been implemented.

"Fourth, I have appointed, in my office, a Government Patent Task Force to examine all aspects of Government patent policy. It has begun its work on the premise that if the Government encouraged its own employees to invent and to apply for patent protection for their inventions, the public interest would be served. If the Government patent policy were such as to give large rewards to the inventor and his commercial backers, I believe that the Government would get far better service from the R&D community; and the people of the United States would see a much greater flow of technology into the real world of commerce."

Dr. Richard W. Roberts reviewed contributions by NBS inventors and mentioned the Bureau's role as a resource available to inventors generally: "In a very broad sense, the Bureau and its work are resources to all inventors, big or small. Our staff is expert in topics ranging from activation analysis to zener diodes, and provides consultation to anyone having problems in our areas of competence.

"New knowledge generated at the Bureau is made available to all inventors through scientific publications, and our volumes of Standard Reference Data are often the key element in a decision as to whether a proposed process is viable or not.

"Other NBS services to inventors are much more direct. In 1964 we created an Office of Invention and Innovation under the direction of Dan DeSimone. One of the functions of this office is to work closely with the National Inventors Council."

Commenting on the Bureau's recently funded Experimental Technology Incentives Program, or ETIP, Dr. Roberts noted that this new program seeks to increase the application of invention and innovation to such problems as productivity, employment, pollution, energy conservation, and our trade balance.

"ETIP will not seek to foster the development of specific new technology, rather it is aimed at the development of Federal policies to stimulate the flow of technology to the marketplace. Before policy can be shaped in a meaningful way, we must have knowledge and experience concerning invention and innovation. And developing that knowledge is the task of ETIP. ETIP assumes that invention in the private sector is strongly influenced by Federal policies and programs. This hypothesis will be tested by conducting experiments in three broad areas: Procurement, regulation, and invention and innovation.

Dr. Roberts stated that ETIP is now defining the desired experiments and statements of work for each of the three major policy questions, after which participation will be solicited from the private sector. Most of the experiments will be performed in cooperation with technologically oriented private organizations and other Federal agencies, with NBS monitoring the progress of these investigations.

ACCIDENT ANALYSTS:

NBS FAILURE SLEUTHS PICK UP PIECES

Dr. Marion L. Picklesimer sometimes receives an elbow in the mail.

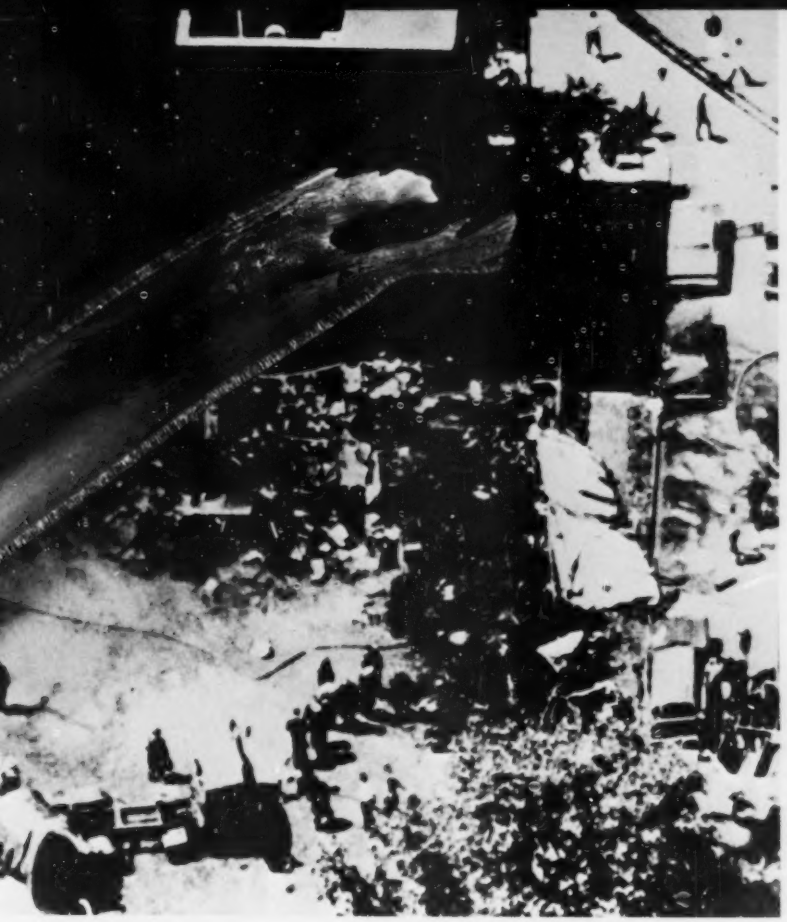
No, he's not a ghoul. Neither is he a physician, although he often examines fractures, scabs, scars, burns, and the like.

Picklesimer, a chemical and metallurgical engineer, is chief of the Mechanical Properties Section in the Bureau's Metallurgy Division. When someone sends him an elbow (as a gas company official in Texas did recently), it is part of a metal pipe assembly (in the case, a gas service line that figured in a Fort Worth suburban explosion fatal to four people) needed for investigative purposes. Why did this tragedy occur, and how can others be prevented? These are the basic questions to be answered by the Department of Transportation with the aid of failure investigators at NBS and other cooperating laboratories.

Pipeline safety is a leading challenge. The United States is crisscrossed by 800,000 miles of natural gas pipelines, some of them dating from the 19th century. But pipelines are not the only structures which fail, with consequences of destruction or death.

NBS scientists and engineers are old hands at failure analysis and participate each year in scores of inquiries, some of historic dimension. These have included the Apollo-13 oxygen-tank explosion; the 1967 collapse of the Point Pleasant Bridge over the Ohio River (that took 46 lives); the 1971 and 1973 earthquakes in the San Fernando Valley, United States, and Managua, Nicaragua (Question: Why did some buildings survive while others were destroyed?); 1969's Hurricane Camille; the 1967 Fairbanks, Alaska, flood; and the 1925 crash of the Navy dirigible *Shenandoah*. There are many others that don't make the history books but give rise to NBS technical analyses used by prevention-minded safety authorities—for example, in cases involving school bus accidents, airplane crashes, tank truck explosions, train derailments, fire-ladder failures, exploding pop bottles, injuries from toys, etc.

What investigators usually find in the wake of a major accident or explosion is a puzzle picture—everything is in fragments, including the accounts of eyewitnesses who in many cases have been through a confusing and terrifying experience. Picklesimer and his colleagues come on the scene later, or perhaps not at all—since



The corroded nuts and bolts and a fragment of structural bracing seen on the periphery of this photograph came from inside Aspiration and Literature, one of the gilded equestrian statues donated by Italy to the American people 22 years ago. NBS metallurgists participated in the National Park Service's investigation of the statuary's extensive deterioration, and helped to draw up restorative procedures.

Explosion of a liquefied oxygen tank truck at Victory Memorial Hospital, Brooklyn, N.Y., touched off a series of fires resulting in the deaths of the driver and a bystander, minor injuries to 30 others, and substantial property damage. The torn and twisted piece of aluminum piping, now on exhibit in Dr. Picklesimer's museum at the Bureau, came from inside the tank. Some idea of the wide area of destruction caused by the explosion can be gleaned from the backdrop of the photograph.

Parts small enough to be contained in a small plastic dish may sometimes loom large in the investigation of major mechanical failures. Shown here are bearings from a fighter aircraft's turbine compressor, failure of which resulted in an aborted mission.

elbows and other parts often are sent to NBS Gaithersburg, Md., laboratories by mail or express.

Typically, the title of an NBS report to the Department of Transportation's Pipeline Safety Office will read: "Examination of Several Components Removed from Site of Natural Gas Explosion...." The reports make technical and undramatic reading, for the moment of truth they seek is attained only in an objective understanding of an accident's technological chain of events. Eyewitness accounts and technical analysts' findings are two sides of the same coin—taken together they may add up to a fairly sound picture of what actually happened, and why.

"Several components" were removed from an explosion site at the hospital in McKeesport, Pa., in January 1972 after a blast destroyed the hospital's boiler room and extensively damaged the hospital's annex building. For one boiler room maintenance man, the moment of truth came with a rumbling noise, a quick look around, and his horrified shout, "Let's get the hell out of here, it's ready to blow."

Gathering together the verbal accounts of eyewitnesses and the mute evidence presented by scattered pieces of structure and equipment, a group of federal, state, engineering-firm, and utility-company officials met a few weeks later at NBS to review all available accident information, map a comprehensive technical investigation, and look over the collected fragments of physical evidence. Up for consideration were:

turn page

ACCIDENT ANALYSTS:
continued

°details of operation of the two boilers in the hospital building

°verbal descriptions of two explosions that came in quick succession

°a reported gas leak in the street near the hospital

°detailed accounts of sights (smoke wisps, etc.) and sounds (thumps, muffled booms, etc.) associated with the accident

°emergency measures (shutting off valves, opening or closing doors, etc.) taken by employees as they recognized the danger

°a copy of the boiler room pressure-volume chart, and a copy of a "normal day" record dating back a month before the explosion

°10 components recovered at the accidents site, including pressure regulators, 8-inch pipe with both sides of a fractured joint, and "a small box containing paper sacks holding debris removed from filter screens and drip legs in the gas train in the regulator station"

°48 photographs made at the explosion site

°blueprints showing regulator station measurements and equipment requirements

°a post-explosion scale isometric sketch of the regulator station, boiler room, furnace gas control system, and piping.

From NBS, the Department of Transportation's pipeline safety officials and the Pennsylvania Public Utility Commission requested scientific examinations and findings on:

°the condition and functioning of the regulators and pressure relief valves

°whether or not the joint fracture had occurred in two separate events a few seconds apart

°whether the material at the joint was faulty

°any additional light that could be cast on the equipment, its operation, and the nature of the explosion.

Dr. Picklesimer and Rober Shives use a scanning electron microscope to study the microstructure (visible in the window) of a piece of metal found at an accident scene.

In carrying out this complex assignment, Picklesimer and his colleagues mapped a series of nine specific types of technical examinations and secured the Washington Gas Light Co.'s cooperation in setting up piping and adapters at NBS for purposes of simulating the actual gas pressure service conditions that had been involved in the McKeesport accident. After months of careful work, NBS turned in a report with 15 technical findings to DOT.

Over the past couple of years the Bureau has worked in this fashion with the Department of Transportation in the investigation and analysis of pipeline failures in Maryland, New Jersey, Pennsylvania, Rhode Island, Texas, and Virginia. The accidents occurred in residential, commerical, and industrial areas, seriously damaging homes, warehouses, and office buildings and sometimes causing death or injury. In addition to Picklesimer's group in the Metallurgy Division, other units located in the Bureau's Center for Building Technology and the Product Evaluation Technology Division have provided technical expertise to investigations. The DOT's National Transportation Safety Board has served as sponsor for certain phases of inquiry.

Without tender loving care, crucial items of physical evidence would be lost in the rubble or carted away by street cleaners. Everything of possible relevance—from paper sacks full of debris to pieces of fractured pipe and samples of soil, rocks, or gravel—must be systematically collected. Produced by explosive upheaval, these artifacts must be disturbed no further, except under controlled laboratory conditions. Thus a typical logbook entry will read: "The 15-inch-long section of pipe containing the undisturbed fracture with the leak clamp intact was packed in a supporting box and ultimately shipped to the NBS Mechanical Properties Section."

So, Picklesimer continues to receive elbows and other parts and materials. He is interested in every simple or compound fracture found in a structural part, every corrosion scab or pockmark, every burn or "insult" (as physicians put it) suffered by a once-glorious human edifice or mechanism that has been brought low. On informal display in a suite of rooms near his laboratory is an assortment of inert objects that played key roles in some grave human dramas, among them the fractured eyebar that figured in the Point Pleasant Bridge collapse.

Picklesimer's collection is more than an educational exhibit—it symbolizes a pivotal aspect of man's struggle for self-improvement and for the attainment of a better, less hazardous life.

IMPROVED ATOMIC FREQUENCY STANDARD UNDERGOING TESTS

The fifth generation of atomic standards for frequency and time-interval has been completed and is being tested at the Bureau's Boulder (Colo.) Laboratories.

The new standard, NBS-5, incorporates many new features for improved stability and accuracy, and shows promise of achieving an accuracy of at least one part in 10^{13}.

NBS-5 takes advantage of recent advances in cesium-beam technology. These include completely redesigned electronics systems which more accurately lock the output frequency of a high-quality quartz crystal oscillator to the cesium transition frequency. NBS-5 has a completely redesigned beam tube with cesium ovens and detectors at both ends so that the beam direction can be reversed. This allows errors caused by small asymmetries in the microwave cavity to be detected on alternate runs. The cavity has been constructed and adjusted to minimize the phase difference between the two ends. Improved, too, are the permanent magnets forming the "optical" system which deflects the cesium beam and focuses it on the detector.

Atomic frequency standards have existed since 1948 when the first "atomic clock," an ammonia absorption device, was built by Dr. Harold Lyons at NBS. Relatively inaccurate by today's standards, it was the first step away from our dependence on the stars for accurate timekeeping. It had a precisely controlled frequency which could be used to drive a clock mechanism, much as a kitchen clock is driven by the 60-Hz powerline frequency.

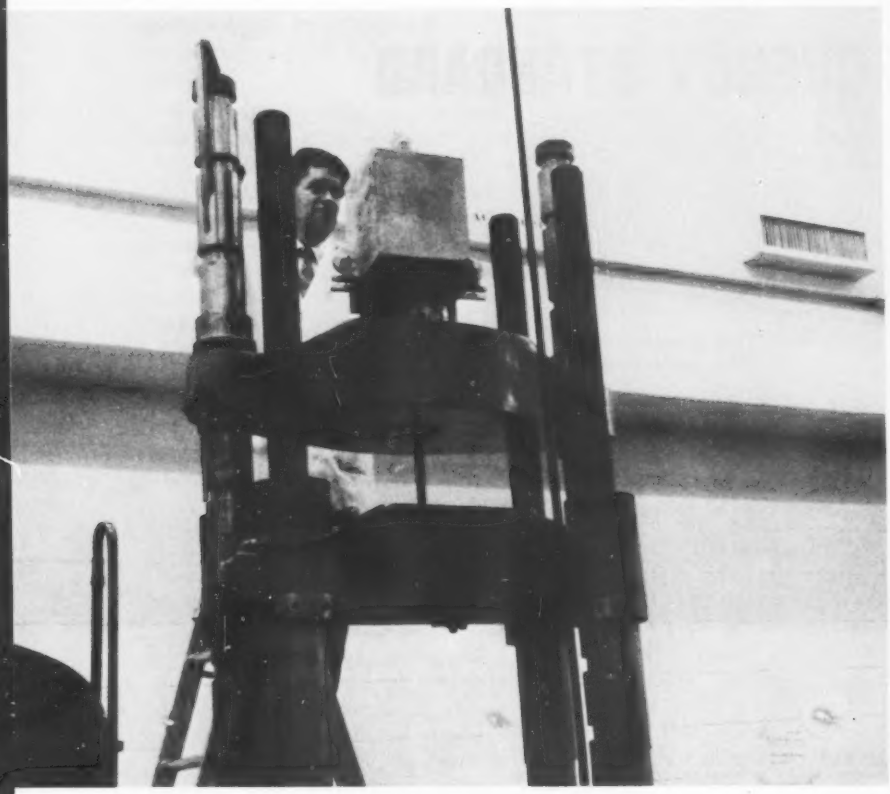
Subsequent research by the Bureau and others indicated that the atomic-beam technique, using cesium atoms, should provide a device superior to one utilizing ammonia absorption.

In a cesium-beam device, the frequency information contained in the cesium atoms is extracted by interrogating them with microwaves. If the injected microwaves match the natural cesium transition frequency, the atoms invert their magnetic orientation as they travel down an evacuated tube. Magnetic fields deflect inverted atoms toward a detector. The detector controls the microwave frequency (derived from a quartz crystal oscillator) by means of a servo system. If the atoms miss the detector, the frequency is automatically corrected until a maximum number of atoms hit the detector. Thus, the cesium resonance frequency controls the frequency of the quartz crystal oscillator. The signal from this locked oscillator is also compared with other devices and could be used for driving a clock.

In actual practice the NBS-5 standard does not drive a clock; instead, it is used periodically to calibrate the frequencies of an ensemble of smaller cesium-beam atomic clocks that run continuously. The reading of this ensemble is then computed, suitably averaged, and designated the Atomic Time Scale of NBS.

Upgrading the primary frequency standard performance involves redesigning all components of the instrument: oscillators, frequency multipliers, beam optics (magnets and collimators), ovens (which generate the atomic beam by heating a small quantity of cesium and directing it down the vacuum tube), detectors, cavity (where the microwaves interact with the atoms), and servo system. All of these elements affect the stability and/or accuracy of the output.

The new standard, NBS-5, is one of the very best frequency standards in existence today, thus clearly keeping the second the most accurately known base unit of our system of measurement.



Two hundred thousand-pound capacity machine applying tension to lower end of rebar protruding from concrete block. Upper "free" (unloaded) rebar end protrudes from top of concrete block.

NBS FINDS WAY TO
REDUCE U.S. HIGHWAY REPAIR COSTS

Premature deterioration of concrete highway bridge deckings cost an estimated $70 million yearly in repairs ... a figure which may be reduced substantially because of recent studies made by the Bureau and the Federal Highway Administration (FHWA).

Concrete bridge deckings, designed for a 50-year service lifetime, frequently require extensive repair, or even replacement, within 5 to 10 years after installation. The cause: cracking and spalling (crumbling) of the concrete.

This deterioration is caused primarily by corrosion of embedded steel reinforcing bars (rebars) when they come in contact with the chloride ions contained in such road deicing chemicals as sodium chloride and calcium chloride.

NBS studies indicate that epoxy coatings, applied as powders by an electrostatic spray technique, provide the best protection—both chemical and mechanical—for steel reinforcing bars. Powdered epoxy coatings were selected because they generally offered better film integrities, fewer film defects, and greater flexibility than liquid epoxies.

THE EVALUATION RPOGRAM

Team members of the Bureau's Center for Building Technology, Dr. James R. Clifton, Manager; Hugh F. Beeghly; Robert C. Mathey; and Erik Anderson, found that organic coatings had not been investigated as a potential solution to the problems incident to steel rebars. Their study encompassed the selection and application of coating systems, evaluation of their protective qualities in a portland-cement concrete-chloride environment, and a study of those mechanical characteristics of the coated bars important to design and structural soundness of bridge decks.

Probably the evaluation program's most *crucial* point was the careful determination of bond strength between coated rebars and concrete; a bridge decking's concrete will crack and fail if its coated rebars move (even slightly) within the concrete when a heavily loaded vehicle crosses.

Table 1. Organic Coatings Materials Evaluated

Type	Uncured state	Number tested
Epoxy	Liquid	21
Epoxy	Powder	15
Polyvinyl chloride	Powder	5
Polyurethane	Liquid	3
Polypropylene	Powder	1
Phenolic nitrile	Liquid	1
Zinc-rich coating	Liquid	1
		47

Forty-seven commercially available organic coating materials (Table 1, above) were evaluated at NBS using a six-part program (Table 2, below).

TABLE 2. PROGRAM OF EVALUATING ORGANIC COATINGS

1. Chemical Resistances of Coating
   A. Resistance to water, calcium chloride, calcium hydroxide and fresh portland cement paste.
   B. Chloride permeability.
2. Physical Durabilities of Coated Rebars
   A. Abrasion and impact resistances.
   B. Flexibilities determined by bending coated rebars.
3. Film Integrity of Cured Coatings
   A. Coverage characteristics; variations in film thickness, etc.
   B. Application method.
   C. Preparation of steel substrate prior to coating application.
4. Electrochemical Measurements of Coated Rebars Immersed in 3 1/2 Percent Sodium Chloride
   A. Electrical potential of steel bar.
   B. Resistance of coating film.
5. Structural Tests of Coated Rebars Embedded in Concrete.
6. Economics

Coating materials shown most promising during screening tests were applied to the steel rebars. With cooperation of industrial firms, commercial off-the-shelf materials and commercial application techniques were used.

Bond strengths were measured by testing "pullout specimens" in which 12-inch lengths of coated rebars were embedded in a 10 × 10 × 12-inch concrete block. Upper and lower specimen ends protruded out of the concrete. A 200,000 lb.-capacity tension machine applied loads to the lower specimen end. The upper "free" end was not loaded by the machine.

During this test, free end and loaded end slippages were measured at each step of higher tension. A formula was used to translate the measurements into bond stress.

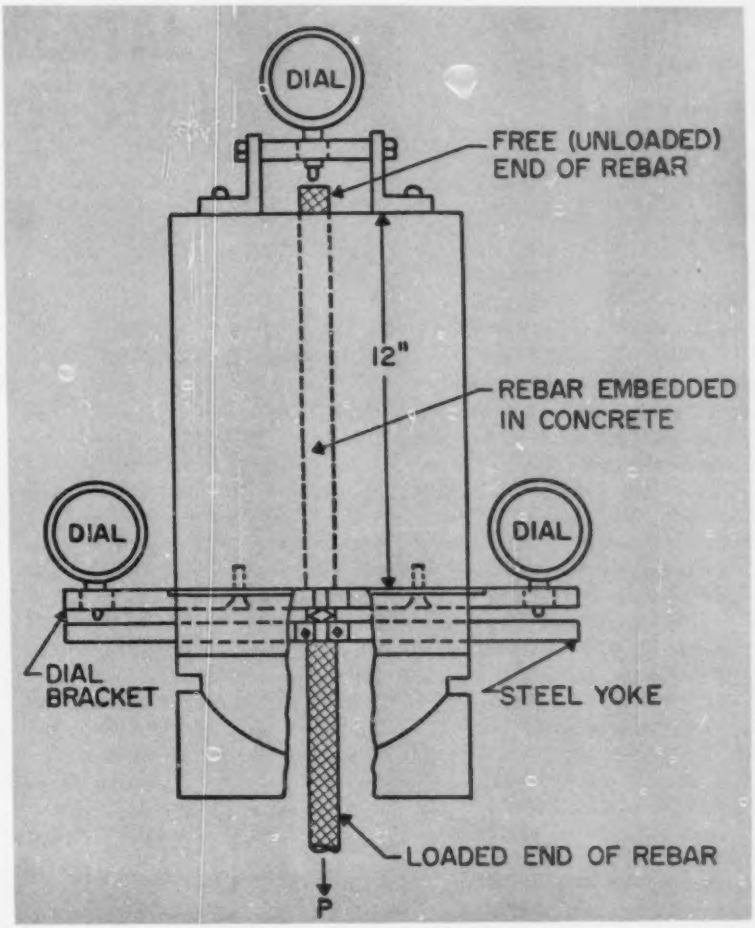


Diagram detailing essential parts of tension machine.

Two bond stress criteria indicated impending bond failure: *free-end slip* of 0.002 inch, and *loaded-end slip* of 0.01 inch.

FINDINGS

On the basis of tests completed thus far, it appears that properly formulated and applied epoxy of 7-mil thickness has adequate flexibility and protective value for use on concrete reinforcing bars. Work by NBS, FHWA, and industrial firms who produce steel reinforcing bars, powered epoxy coatings, and applicators is continuing. However, as a result of the recent NBS test, the FHWA feels that construction of experimental bridge decks with epoxy-coated reinforcing bars is justified. FHWA is encouraging its Implementation Division and State Highway Departments to design and build bridge decks embodying the NBS test findings within the next two construction seasons. It is felt that the coated rebars will assist in realizing the full design life of bridge deckings.

Automated buoys provide environmental data useful in weather forecasting and marine research. Photo courtesy of the National Oceanic and Atmospheric Administration.

NEW ENVIRONMENTAL BUOY CABLES TESTED

How do you reliably telemeter data up through 1,700 feet of ocean, using a cable that must also anchor a 100-ton buoy?

Coaxial cable represents the ideal transmission medium but how could it withstand the dynamic tensile forces exerted on it by the buoy?

The Bureau has been testing one promising system—a specially fabricated copper-conductor and synthetic fiber mooring line which serves as the center conductor of a coaxial cable. Sea water acts as the outer conductor. The automated buoys were designed by the National Oceanic and Atmospheric Administration to provide environmental data deemed useful in weather forecasting and marine research. Since they are meant to operate unattended up to a year at a time, simplicity and reliability of the data transmission line is most important.

Data generated by submerged sensors are telemetered to the surface and relayed via radio-to-shore stations. The sensors measure salinity, pressure, currents, temperature, and the speed of sound at various depths. The buoy overhead carries additional sensors that measure atmospheric conditions, plus the necessary generators, batteries, radio transmitters, and data-storage facilities.

The combination mooring line data line (MLDL) is fabricated from insulated copper wire and synthetic fiber rope. The rope provides the strength; eight insulated "center conductors" connected in parallel and fastened at both ends ensure continued reliable operation if one or more conductors break. The sensor packages, spaced along the cable at various depths, are coupled to the cable through toroidal coils. Direct electrical connections would have jeopardized the integrity of the insulation, whereas inductive couplers, which surround the cable but do not penetrate the insulation, reduce the chances of salt-water corrosion.

The lower ends of the center conductors are connected to a ground plane consisting of a sheet of bare metal that provides a low-resistance path to the sea water. Equipment on the buoy connects between the upper ends of the conductors and another submerged metal ground plane. Size and configuration of these ground planes were determined by tests made at the NBS Boulder (Colo.) Laboratory at the same time as the MLDL tests.

NBS evaluated the electrical characteristics of the MLDL utilizing both time-domain reflectometry (TDR) and frequency-domain reflectometry techniques. TDR is a technique somewhat similar to a one-dimensional radar. A pulse of electromagnetic energy is sent down the data line and the reflected pulse is analyzed with an oscilloscope. Characteristics of the reflected pulse indicate defects, discontinuities, kinks, or other features of the line. The time interval for the pulse to return provides information that gives the location of these features; and the pulse height, slope, and other characteristics give information about the nature of the feature. The frequency-domain analysis involves comparing the electrical characteristics of the cable at many different frequencies.

Both techniques provide information to determine the characteristic impedance, signal-propagation velocity, reflection coefficients, self-inductance, wire-to-water capacitance, series resistance, shunt conductance, current standing-wave pattern, and the effects of toroidal couplers. TDR was also used to determine the position of the couplers along the line. All the above electrical parameters were examined for their sensitivity to changes in length, salinity, and temperature. Interaction between individual conductors of the MLDL was analyzed by exciting some while measuring the output of the others.

All tests were done vertically and horizontally in the ocean. The results demonstrated the feasibility of the MLDL concept, and established that the TDR method was a particularly useful technique for maintenance analysis after the buoys are developed.

Mr. Irwin Benjamin (left), Chief of the Building Fires and Safety Section of the Structures, Materials, and Life Safety Division, shows Dr. P. H. Thomas, Division Head of the British Fire Research Station, the smoke density chamber used to study smoke produced by burning building materials.

NBS SMOKE TEST GAINS ACCEPTANCE

A smoke density test developed at NBS is gaining wide acceptance in determining the smoke generated from various building materials during fires.

More deaths in fires occur from smoke and asphyxiation than from burns. Materials generating less smoke not only cut down on carbon monoxide and other toxic products but also lessen the obscuring of vision which so often hinders rescue and prevents escape. Smoke is also responsible for considerable property damage. Yet little data on smoke production are available to building designers, owners, or code officials in selecting materials of construction and furnishings for low-risk facilities.

The smoke density test, developed at the Center for Building Technology, has been widely adopted for use in testing the

smoke-generating properties of building materials, according to Thomas G. Lee, an engineer, in a new publication just released by NBS.[1] Since 1966, when the test method was originally described, a considerable body of test information has been collected and published by industrial and Government research laboratories.

Until 1966, there was no meaningful and accurate test method suitable for measuring over a wide range of smoke concentrations. In that year NBS developed the smoke density chamber, which meets all the requirements of a good laboratory test method for measuring smoke generated by materials. These requirements are that results be relevant and useful, reliable and quantitative; that the method provide a continuous scale of measure and have sufficient resolution to cover the common materials; and that the results be understandable to user groups and fit the concept of performance criteria in building code enforcement.

In an evaluation of 22 test chambers in as many industrial, research, and testing laboratories in the United States and Canada, the NBS-developed chamber test procedure has been shown to produce accurate and reproducible results.[2] The median reproducibility (found among laboratories evaluated) for a variety of materials was about 8 percent. Eight common building materials were tested, using prescribed flaming and nonflaming exposure conditions. A further result of the evaluation was the development of a set of procedural changes included in the latest submission to the American Society for Testing and Materials for consideration and possible promulgation of the method as a voluntary standard.

The chamber is an 18 ft^3 closed cabinet in which a specimen 3 inches square is supported vertically in a holder and is exposed to heat under one of two conditions, designated as "flaming" or "nonflaming" (smoldering). The thickness and mounting of the test specimens should match the end use (installation) thickness and mounting. For each specimen, the combustion-generated smoke accumulates within the chamber and the reduction of light transmission during the test is measured by a photometer and reported in terms of optical density of the smoke. The principle of smoke measurement in the chamber is based on application of the law of light absorption through solid or liquid aerosols, commonly referred to as the Beer-Lambert Law. Optical density is the single measurement most characteristic of a "quantity of smoke." The data from the chamber give both the maximum specific optical density and the rate of increase in optical density during the test. To simplify use of test results, however, only the maximum specific optical density, D_m, is used to estimate the potential smoke generation of materials in building fires. The range of the instrument, between 0 and 800 units, adequately covers the D_m levels for most building finish materials.

In addition to smoke density measurement, the chamber can also measure the concentration of potentially toxic gases and vapors.

Since the test does not measure an *inherent* property or "smoke characteristic" of a material, it is not possible to predict smoke production from a specimen without testing. Thus, specimens submitted for testing should be identical in all respects (including thickness) to those used in the field. Also, in regarding building code requirements, officials should take limitations on the use of materials into consideration. Their potential smoke production may vary depending on such factors as: type of occupancy, level of risk, fire experience, and the kind of built-in fire protection.

NBS provides two standard reference materials (SRM's) to check the performance of the chambers under flaming and nonflaming conditions. They are SRM's 1006 and 1007, Smoke Density Chamber Standards: Alpha cellulose-NM Flaming Exposure condition; and Plastic Material Flaming Exposure condition.

Table 1. **Results of Interlaboratory Evaluation of Smoke Density Chamber Test**

Specimen	Thickness in.	Mean D_m	Reproducibility Coefficient of variation %	Repeatability Coefficient of variation %
Nonflaming Exposure				
Limoleum	0.125	725	6.7	6.4
Polypropylene Rug	0.22	621	8.4	4.5
Red Oak	0.25	552	7.2	3.2
ABS/.022	0.022	188	11	6.4
α-Cellulose	0.03	162	2.9	2.6
PVC-Gypsum	0.50	109	6.0	3.2
Polystyrene Foam	1.0	23	27	29
Flaming Exposure				
GRP	0.062	719	6.8	5.0
ABS/.032	0.032	451	3.8	4.5
Polystyrene Foam	1.0	391	13	8.0
Polypropylene Rug	0.22	292	8.3	6.9
PVC-Gypsum	0.50	109	27	11
Acoustic Tile	0.75	23	12	16

[1] Lee, T. G., The Smoke Density Chamber Method for Evaluating the Potential Smoke Generation of Building Materials, Nat. Bur. Stand. (U.S.), Tech. Note 757 (1973).

[2] Lee, T. G., Interlaboratory Evaluation of Smoke Density Chamber, Nat. Bur. Stand. (U.S.), Tech. Note 708 (1971).

Cobol *continued*

classify a compiler according to each level of the Federal COBOL Standard which it has met.

Ambiguities encountered in validation tests will be referred to a Federal COBOL Interpretation Committee chaired by NBS. This group will be responsible for prompt resolution of questions involving interpretation of the current Federal Standard and will insure consistent interpretation contributing to the objectives of the Standard.

FCCTS will operate on a pilot basis during its first year, and under a temporary Federal Property Management Regulation now being coordinated among the agencies responsible for implementation of Public Law 89-306 (Brooks Bill). The test routines and associated documentation[2] are being made available to vendors for detailed review, and the pilot experience will give the needed opportunity for compiler modifications to meet all tests.

Concurrently, NBS is working on similar test routines for the FORTRAN programming language, in anticipation of applying a comparable approach should a Federal FORTRAN Standard be adopted in the future. An initial set of routines for ANSI FORTRAN (1966) is expected to be distributed to vendors for review during the summer of this year.

This major step pending in COBOL is an excellent example of cooperation among departments to solve a major compatibility problem in the Federal ADP community. The NBS Institute for Computer Sciences and Technology is continuing to develop the procedural and technological means that allow this effective approach on other compatibility problems to make use of the Government's technical expertise.

[1] Baird, G. N., The DoD COBOL Complier Validation System, Proc. Fall Joint Computer Conference, 1972, 819-827.

[2] Chief of Naval Operations, Information Systems Division (OP 91), Navy COBOL Compiler Validation System—User's Guide, January 1973.

NBS FINDS CAUSES OF PAPER DEGRADATION

A previously unrecognized cause of paper deterioration has been found by a Bureau scientist. Attention has focused on the fibers determining paper quality. But Dr. Edmond L. Graminski, a materials scientist, has discovered that the extent to which certain properties deteriorate, causing the paper to fail, is partly independent of fiber quality itself.

Electron photomicrographs of paper indicate the presence of a film-like material in addition to the paper fibers. This material, described as a matrix, consists of small densely packed fibers. It is produced when the pulp is processed mechanically prior to papermaking.[1] The matrix spans the areas between the fibers and decreases their ability to move laterally or to twist when the paper is strained. Cracks develop in this film-like material when the paper is bent back and forth (flexing), resulting in decreased stiffness.

Tests by Graminski and his colleagues indicate that this matrix contributes significantly to the firmness of the paper, and that modification of the matrix would result in key changes in paper properties (breaking strength, stiffness, folding endurance, modulus, etc.). Supporting this discovery is the finding that although one high-grade paper was the most durable of the papers investigated, its retention of some physical properties (i.e., bending, stiffness, and modulus) was not always the highest.

Matrix modification might be accomplished through paper converting processes such as saturation with synthetic latexes and the addition of plasticizers. Important new paper products and new uses of paper-like material may be anticipated. Also entirely new, simplified, and less costly ways of making paper may be possible.

The amount of matrix appears to be proportional to the air permeability of the paper: One paper with a very low air permeability had a high proportion of matrix constituent; another paper with a smaller proportion of matrix had a higher air permeability.

To conduct these paper-deterioration tests, NBS designed and constructed a machine to accelerate deterioration of paper properties by flexing the paper in a uniform and reproducible manner.

The study concluded:

°The flexing test designed for this investigation appears to be a suitable method for evaluating the relative durability of paper;

°Paper appears to resemble a fiber-reinforced plastic, with a matrix apparently consisting of a film-like portion produced during mechanical processing of the pulp;

°The matrix seems to have a significant effect on the paper's retention of bending stiffness during handling.

"The study appears to have provided significant clues for the design of paper documents capable of retaining stiffness when subjected to machine processing," Dr. Graminski said. Development of matrix manipulation techniques should lead to the solution of this increasingly vexatious problem.

[1] The Effect of Flexing on the Mechanical Properties of Paper, Edmond L. Graminski, Paper Evaluation Section, Product Evaluation Technology Division, National Bureau of Standards, Washington, D.C. 20234. To be presented to the Fundamental Research Symposium, Cambridge, England September 1973.

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